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TO: Office of Grants and Research Contracts
National Aeronautics and Space Administration
Washington, D. C. 20546

FROM: P. F. Maeder, Chairman, Space Sciences Committee

SUBJECT: Semi-Annual Report
NASA Grant NGR-40-002-009
June 1, 1965 - November 30, 1965

The Space Sciences Committee at Brown University met in June 1965 and decided to make the following awards to junior staff members at Brown University, in accordance with the purpose of the grant:

Professor J. C. Baird, Jr. (Chemistry) Part I: "Studies in Atomic and Molecular Physics and Chemistry having Astrophysical Interest"; Part II: "Exobiology".

Professor A. Houghton (Physics) "Instabilities of One and Two Component Plasmas"

Professor S. K. F. Karlsson (Engineering) "Interaction of the Solar Wind with the Earth's Magnetosphere: A Laboratory and Analytical Study"

Professor J. F. Kidwell (Biology) "Genotype and Environment Interaction"

Professor T. A. Mutch (Geology) "Identification of Extraterrestrial Particles in Ancient Sedimentary Rocks"

Research work on these projects was started immediately and individual progress reports covering the above period are attached.

In addition to the individual research projects, a seminar program with invited speakers in the area of space sciences was initiated in September. Professor Baird of the Chemistry Department took charge of this program and the following is a quote from his report:

"During the first academic semester of 1965-66 we have had three speakers before our Space Sciences Colloquium. Professor Carl Sagan, Harvard University, spoke about the information available concerning life on Mars as seen through Mariner pictures. Dr. Eugene Shoemaker, Chief Astrogeology Branch, U. S. Geological Survey, Flagstaff Arizona, discussed his ideas about "Geologic Processes on the Moon". Finally, Dr. A. G. W. Cameron, Goddard Institute for Space Studies, spoke on "The Origin of the Solar System".

"All the talks, thus far, have been on a more or less non-technical level. The audiences have been large, the order of 120-140, and have consisted of Brown University faculty 10-15%, many graduate students, undergraduate students and quite a number of visitors from the surrounding community. The local press, and radio and television media have been informed of our seminars and usually cover these events.

"In the future we plan to have Dr. Robert Fellows speak about the Voyager program. Other topics we hope to include are the Manned Orbiting Laboratory and Balloon telescopic observations."

Effective January 1, 1966, two additional projects are to be added to the program, and they are:

Professor Barrett Hazeltine (Engineering) "Study of a Tactile Communication System"

Dr. Fred H. Pollak (Physics) "Effect of Static and Modulated Uniaxial Stress on the Band Structure of Semiconductors".

In general, we believe it is possible to say that the program has gotten off to an excellent start and has met with considerable interest. The exchange of ideas between the various fields participating is very lively and we believe will result in considerable multidisciplinary activity as time goes on. The interest this effort is meeting with, in the university community as well as outside the university, is evidenced by the attached newspaper article which contains an excellent layman's description of the various research projects.

P. F. Maeder

PFM:jmm

Enclosures (6)

[redacted]

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Progress Report on Research Project

Part I: "Excited States in Molecular Nitrogen"

The purpose of this research is to observe radiofrequency transitions between energy levels in excited electronic states of molecular nitrogen. The energy level spacings responsible for the transitions have an important bearing on the excited state molecular wave functions for nitrogen. It is also possible that the radiofrequency transitions may have astrophysical importance.

During the last few months we have constructed an observation cell and a highly stabilized 100 watt microwave generator for use in exciting a light source. Molecular nitrogen excitation sources are now being built.

Personnel: C. Lee, Eliot Weinstock, J. C. Baird, Principal Investigator

Part II: "Exobiology"

Many biological systems contain paramagnetic centers which can be detected by electron paramagnetic resonance. We have found that lichens have a strong paramagnetic resonance spectrum. It may be possible to use this fact to determine whether there are similar forms of life on other planets by sending suitable instrumentation. The minimum information, providing spectra were observed, would be positive identification of organic radicals.

In our project we have been attempting to isolate the paramagnetic components in order to obtain some information about them. So far the lichen paramagnetic resonance consists of at least two components; an inorganic fraction and an organic radical. We have, using simple chemical separation procedures, been able to isolate one organic radical fraction. Its molecular weight is less than 5000.

Personnel: J. C. Baird

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Progress Report on Research Project

"Instabilities of One and Two Component Plasmas"

I. Collective Excitations of One and Two Component Plasma's in a Magnetic Field.

The collective excitations of a one-component plasma (at densities appropriate to both metals and semiconductors) in a magnetic field have been studied: arbitrary directions of propagation with respect to the magnetic field have been considered. The method employed has been to use the one-particle density matrix equation, modified to take into account electron-impurity collisions, to determine the frequency and wave vector dependent conductivity tensor $\sigma_{\mu\nu}(q,\omega)$. The response determined in this way is then made self consistent with Maxwell's equations.

The first part of our project has been to investigate the effect's of collision damping on the collective excitations of the plasma in the long-wavelength limit i.e. $q \to 0$. An investigation of this approximation revealed the possibility of extra damping i.e., Landau and Doppler Shifted Cyclotron resonance damping whenever $(n\omega_c - \omega) < qv_F$, where (n) is an integer. This additional damping exhibits Giant Quantum Oscillations if $kT < \omega_c$, the cyclotron frequency. However, if $kT > \omega_c$ the oscillations broaden into a uniform enhanced damping. The structure of the Landau and Cyclotron damping has been studied for arbitrary direction and mean free path, care has been taken to include the diffusion current which is important when $q \neq 0$. A report on this work is now being prepared for publication.

II. Coupling of Plasma Waves to Polar Phonons in Degenerate Semiconductors.

A program to investigate the coupling between optical phonons and the collective oscillations of the electron plasma in degenerate semiconductors, in the presence of a static magnetic field, has been instigated. At appropriate carrier densities (10^{17} to 10^{18} in III-V compounds) the free carrier plasma frequency is comparable to the optical frequency and the plasma waves and phonons cease to be independent excitations of the system. The new normal modes of the system are now in fact strong admixtures of phonons and plasmons. To date we have studied the mixing in the long-wavelength limit, an extension of the theory to finite wavelengths is in progress.

Personnel: A. Houghton, Principal Investigator, and P. R. Beaudet

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Progress Report on Research Project

"Interaction of the Solar Wind with the Earth's Magnetosphere:
A Laboratory and Analytical Study"

1. Experimental work.

A breakdown of the plasma wind tunnel has made necessary changes in the design of the ion source. The rebuilding of the source is now in progress. In connection with the Annual Meeting of the Fluid Dynamics Division of the American Physical Society in Cleveland, November 22-24, Professor Karlsson visited the ion propulsion group at the Lewis Research Center and discussed with them the relative merits of a contact ionization ion source (which we presently have) and an electron bombardment ion source. As a result of these conversations, we are also working on the design of an electron bombardment ion source suitable for the plasma wind tunnel.

We are taking a careful look at the instrumentation necessary to properly monitor the performance of the plasma wind tunnel and make suitable measurements. The external circuitry is now being redesigned. It has been found that a small permanent magnet may be used for a terrella and this will provide both Larmor radii and magnetosheath dimensions in the right range.

This work is being carried out by Mr. L. G. Cohen and Professor S. K. F. Karlsson and is partly supported by N.A.S.A.

2. Analytical study.

The theoretical model of the solar wind impinging on the earth's dipole magnetic field has been formulated using the one-fluid magnetohydrodynamic equations. This could be effected because the Debye length is by far the smallest length scale occurring so charge separation is negligible. Moreover because of the largeness of the megnetic Reynolds number, there is a thin layer [thickness $O(R_E Re_M^{-1/2})$, R_E = earth radius, Re_M = magnetic Reynolds number] which shields the earth from the solar wind and the solar wind from the earth's dipole field. This is called the magnetosheath. We have found that only if there is an interplanetary magnetic field and only if the velocity of the charged particles in the solar flux falls within definite bounds can there be a (collisionless) magnetohydrodynamic shock wave standing in front of the magnetosheath. No gasdynamic type shocks can exist because the mean free path is larger even than the earth-sun distance (1AU) -- by far the largest length in the problem. We are now examining the structure of the magnetosheath. In this thin boundary layer, we have succeeded in reducing the governing conservation laws and Maxwell's equations to two second order nonlinear partial differential equations for the vector potential of the magnetic field and the plasma density. We suspect that the structure of the magnetosheath may be drastically affected by the presence of the shock wave. For example, density profiles may be sufficiently different that, in an experiment, the presence of an otherwise "invisible" shock may be deduced by a measurement in the magnetosheath.

This research is being conducted by Mr. L. G. Cohen with the advice and assistance of Professor I. M. Cohen.

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Progress Report on Research Project

"Genotype and Environment Interaction"

Most of the effort during the first six months was devoted to preparation for experimental work. Nine isogenic lines of Drosophila melanogaster have been formed. A marked inversion technique has been used to make the eight homozygous types arising from a cross of two lines, holding the fourth chromosome constant. Appropriate crosses among these eight lines will provide the 27 possible genotypes. These crosses will be made in January 1966 for the first experiments.

Six highly inbred lines of mice have been obtained, and are ready for the experimental phase.

The first space simulated environment to be studied is the vibration encountered as "lift-off" and "re-entry" of space vehicles. Vibration equipment is available in the Division of Engineering and has been tested. The first experiments, to be conducted in January 1966 will determine the effects of vibration (100 C.P.S. at an amplitude of .4mm for periods of 5, 10, 15, 20 and 25 minutes) on (1) the production of chromosomal oberrations in somatic cells in tissue culture (2) crossing over in male Drosophila and (3) the production of point mutations in Drosophila.

Personnel: J. F. Kidwell, Principal Investigator

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Progress Report on Research Project

"Identification of Extraterrestrial Particles in Ancient Sedimentary Rocks"

Special facilities have been prepared in Rhode Island Hall for the processing of material. This includes a clean room, completely lined with formica and glass. The inner clean room is separated from the rest of the building by two buffer areas. A forced air intake maintains positive pressure within the inner room.

A number of rock samples have been obtained. These include salts of Silurian, Permian, and Jurassic age both from North America and Europe, Jurassic cherts from Europe, Devonian cherts from North America, and Precambrian cherts and limestones from North America and Africa.

Disaggregation and solution procedures for rocks of varying composition almost completely have been worked out. Salts and limestones are soluble in weak acids which do not affect silicates or oxides. Cherts can be partially disaggregated in HF acid. Such disaggregation does not have appreciable effect on oxides but surely dissolves some silicate minerals.

Preliminary fractionation of insoluble residues is accomplished magnetically. The highly magnetic fraction contains magnetite spherules which are probably formed - in part, at least - by ablation of infalling meteorites. Spherule abundances considered as a function of depositional time and surface area are generally constant between samples. Unusual spherule enrichment in some samples, however, does occur. The most striking example of such enrichment is exemplified by a Devonian chert just processed. The epherule abundances here make possible certain microscopic and chemical analyses not possible with the usual smaller samples. Unusually high spherule abundances are tentatively considered a consequence of a meteorite passing directly over the depositional site at a low altitude.

Search for extraterrestrial particles other than magnetite spherules will concentrate on glasses, either of an impact or ablation melt origin. Impact glasses might include lunar ejecta trapped in the earth's gravitational field. The reality of such glasses is demonstrated on a larger particle scale by in situ partially glassy rocks around terrestrial craters and by tektites. Glassy particles are easily identified by their isotropic nature. Accordingly the search for such particles in sedimentary rock residues is considered feasible even though their relative abundance is probably exceedingly small.

Personnel: Thomas A. Mutch, Principal Investigator